Entergy

Entergy Operations, Inc.
1340 Echelon Parkway
Jackson, Mississippi 39213-8298
Tel 601-368-5758

F. G. Burford
Acting Director
Nuclear Safety & Licensing

CNRO-2004-00018

March 11, 2004

U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555

SUBJECT: ANO-2 Relaxation Request #4 to NRC Order EA-03-009 for the Control Element Drive Mechanism Nozzles

Arkansas Nuclear One, Unit 2
Docket No. 50-368
License No. NPF-6

REFERENCES:

1. Entergy Operations, Inc. letter CNRO-2003-00033 to the NRC, dated August 27, 2003
2. Entergy Operations, Inc. letter CNRO-2003-00039 to the NRC, dated September 12, 2003
3. Entergy Operations, Inc. letter CNRO-2003-00047 to the NRC, dated September 25, 2003
4. Entergy Operations, Inc. letter CNRO-2003-00050 to the NRC, dated October 2, 2003
5. Entergy Operations, Inc. letter CNRO-2003-00052 to the NRC, dated October 8, 2003
6. NRC letter to Entergy Operations, Inc. (TAC No. MB9542), dated October 9, 2003

Dear Sir or Madam:

In Reference #1, Entergy Operations, Inc. (Entergy) requested relaxation from Section IV.C.(1)(b) of NRC Order EA-03-009 for Arkansas Nuclear One, Unit 2 (ANO-2) via ANO-2 Relaxation Request #1. Specifically, the bottoms of the ANO-2 control element drive mechanism (CEDM) nozzles contain threads that cannot be effectively examined in accordance with the Order. Entergy provided supplemental information pertaining to this request via Reference #s 2 – 5. In Reference #6, the NRC staff granted Relaxation Request #1 for one operating cycle, which ends with upcoming refueling outage 2R17.

A101

The conditions that required Entergy to submit relaxation to the Order remain under the requirements of the revised Order (i.e., CEDM nozzle configuration). Therefore, pursuant to Section IV.F of NRC Order EA-03-009 (revised), Entergy requests relaxation from Section IV.C.(5)(b) of the Order for ANO-2. As with Relaxation Request #1, this request (ANO-2 Relaxation Request #4) proposes an alternative based on stress and fracture mechanics analyses. ANO-2 Relaxation Request #4 is provided in Enclosure #1.

In support of Relaxation Request #1, Entergy submitted Engineering Report M-EP-2003-002, Rev. 1, *Fracture Mechanics Analysis for the Assessment of the Potential for Primary Water Stress Corrosion Crack (PWSCC) Growth in the Uninspected Regions of the Control Element Drive Mechanism (CEDM) Nozzles at Arkansas Nuclear One Unit 2*, and Dominion Engineering, Inc. Letter L-4162-00-1, *Material Properties and Modeling Methods Used in ANO Unit 2 Welding Residual Stress Analyses*, to the NRC via Reference #1. Both documents also support Relaxation Request #4.

This letter contains commitments as identified in Enclosure 2.

If you have any questions or require additional information, please contact Guy Davant at (601) 368-5756.

Sincerely,

Ron Byrd for FGB

FGB/GHD/ghd

Enclosures: 1. ANO-2 Relaxation Request #4
2. Licensee-Identified Commitments

cc: Mr. W. A. Eaton (ECH)
Mr. J. S. Forbes (ANO)

Dr. Bruce S. Mallet
Regional Administrator, Region IV
U. S. Nuclear Regulatory Commission
611 Ryan Plaza Drive, Suite 400
Arlington, TX 76011-8064

U. S. Nuclear Regulatory Commission
Attn: Mr. T. W. Alexion
Washington, DC 20555-0001

NRC Senior Resident Inspector
Arkansas Nuclear One
P. O. Box 310
London, AR 72847

ENCLOSURE 1

CNRO-2004-00018

ARKANSAS NUCLEAR ONE, UNIT 2
RELAXATION REQUEST #4

ENTERGY OPERATIONS, INC.
ARKANSAS NUCLEAR ONE, UNIT 2

RELAXATION REQUEST #4 TO NRC ORDER EA 03-009

I. ASME COMPONENTS AFFECTED

Arkansas Nuclear One, Unit 2 (ANO-2) has ninety (90) ASME Class 1 reactor pressure vessel (RPV) head penetration nozzles comprised of eighty-one (81) Control Element Drive Mechanism (CEDM) nozzles, eight (8) Incore Instrument (ICI) nozzles, and one (1) vent line nozzle. This request pertains to the CEDM nozzles only. See Figure 1 for penetration locations on the ANO-2 RPV head.

In accordance with Section IV.A of NRC Order EA-03-009, the ANO-2 susceptibility category is "high" based on a calculated value of greater than 12 effective degradation years (EDY) at the beginning of the upcoming fall refueling outage, 2R17.

II. NRC ORDER EA 03-009 APPLICABLE EXAMINATION REQUIREMENTS

The NRC issued Revised Order EA-03-009 (the Order) that modified the current licenses at nuclear facilities utilizing pressurized water reactors (PWRs), which includes ANO-2. The Order establishes inspection requirements for RPV head penetration nozzles. ANO-2 is categorized as a "high" susceptibility plant based on an EDY value greater than 12.

Section IV.C of the Order states in part:

> All Licensees shall perform inspections of the RPV head using the following frequencies and techniques:
>
> (1) For those plants in the High category, RPV head and head penetration nozzle inspections shall be performed using the techniques of paragraph IV.C.(5)(a) and paragraph IV.C.(5)(b) every refueling outage.

Section IV.C.(5) of the Order states in part:

> (5) Inspections of the RPV head shall be performed as directed in paragraphs IV.C.(1), IV.C.(2), IV.C.(3), and IV.C.(4) using the following techniques:
>
> (a) Bare metal visual examination of 100% of the RPV head surface (including 360° around each RPV head penetration nozzle).
>
> (b) For each penetration, perform a nonvisual NDE in accordance with either (i), (ii), or (iii):
>
> (i) Ultrasonic testing of the RPV head penetration nozzle (i.e., nozzle base material) from 2 inches above the highest point of the root of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) to 2 inches below the lowest point at the toe of the J-groove weld on a horizontal plane perpendicular to the nozzle axis (or the bottom of the nozzle if less than 2 inches); OR from 2 inches above the highest point

of the root of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) to 1.0 inch below the lowest point at the toe of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) and including all RPV head penetration nozzle surfaces below the J-groove weld that have an operating stress level (including all residual and normal operating stresses) of 20 ksi tension and greater. In addition, an assessment shall be made to determine if leakage has occurred into the annulus between the RPV head penetration nozzle and the RPV head low-alloy steel.

(ii) Eddy current testing or dye penetrant testing of the entire wetted surface of the J-groove weld and the wetted surface of the RPV head penetration nozzle base material from least 2 inches above the highest point of the root of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) to 2 inches below the lowest point at the toe of the J-groove weld on a horizontal plane perpendicular to the nozzle axis (or the bottom of the nozzle if less than 2 inches); OR from 2 inches above the highest point of the root of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) to 1.0 inch below the lowest point at the toe of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) and including all RPV head penetration nozzle surfaces below the J-groove weld that have an operating stress level (including all residual and normal operating stresses) of 20 ksi tension and greater.

(iii) A combination of (i) and (ii) to cover equivalent volumes, surfaces, and leak paths of the RPV head penetration nozzle base material and J-groove weld as described in (i) and (ii). Substitution of a portion of a volumetric exam on a nozzle with a surface examination may be performed with the following requirements:

1. On nozzle material below the J-groove weld, both the outside diameter and inside diameter surfaces of the nozzle must be examined.

2. On nozzle material above the J-groove weld, surface examination of the inside diameter surface of the nozzle is permitted provided a surface examination of the J-groove weld is also performed.

III. REASON FOR REQUEST

Section IV.F of the Order states in part:

Licensees proposing to deviate from the requirements of this Order shall seek relaxation of this Order pursuant to the procedure specified below. Project Directors or higher management positions in the Division of Licensing Project Management of the Office of Nuclear Reactor Regulation, may, in writing, relax or rescind any of the above conditions upon demonstration by the Licensee of good cause. A request for relaxation regarding inspection of specific nozzles shall also address the following criteria:

(1) The proposed alternative(s) for inspection of specific nozzles will provide an acceptable level of quality and safety, or

(2) Compliance with this Order for specific nozzles would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

Requests for relaxation associated with specific penetration nozzles will be evaluated by the NRC staff using its procedure for evaluating proposed alternatives to the ASME Code in accordance with 10 CFR 50.55a(a)(3).

Pursuant to Section IV.F(2) of the Order, Entergy Operations, Inc. (Entergy) requests relaxation from the requirements of Section IV.C.(5)(b). Entergy plans to inspect RPV head CEDM penetration nozzles at ANO-2 using the ultrasonic testing (UT) method in accordance with Section IV.C.(5)(b)(i) of the Order to the maximum extent possible. However, a UT inspection of the inside diameter (ID) of the CEDM nozzles at ANO-2 can only be performed from 2 inches above the J-groove weld down to a point approximately 1.544 inches above the bottom of the nozzle. This 1.544-inch "blind zone" is due to limitations resulting from CEDM nozzle configuration (1.344 inches) and inspection probe design (0.200 inch). These limitations and their associated hardships are discussed in Sections III.A and III.B.

Entergy also evaluated the impact of inspecting the blind zone of each CEDM nozzle using either the liquid penetrant testing (PT) method or the eddy current testing (ECT) method as specified in Section IV.C.(5)(b)(ii) of the Order. Entergy found impracticality and hardship with these techniques, as discussed in Section III.C.

A. <u>Nozzle Configuration Limitation</u>

1. <u>Description</u>

Guide cones are attached to the bottoms of the ANO-2 CEDM nozzles via threaded connections. Specifically, the guide cone screws into the end of the CEDM nozzle with a welded set screw and two tack welds at the cone-nozzle interface to secure the guide cone to the nozzle. The length of the threaded connection region is 1.25 inches. Additionally, a 45° chamfer exists immediately above the threaded connection region. The length of the chamfer region is 0.094 inch. (See Figure 2 for typical nozzle details.)

Due to the threaded connection and chamfer region at the bottom of each CEDM nozzle, a meaningful UT examination in that area cannot be performed. Specifically, the chamfer region geometry causes sporadic signals while, once the guide cone is reached, sound cannot pass into the CEDM nozzle base material because of the gap that exists between the guide cone and the nozzle at the threaded connection. Therefore, UT of the bottom 1.344 inches (1.25 + 0.094) of the CEDM nozzles is not possible.

2. Hardship

Resolving the UT limitations due to nozzle configuration would require eliminating the existing CEDM nozzle-to-guide cone threaded connection and chamfer region and redesigning and physically modifying the nozzle ends to provide for an acceptable UT examination. Entergy believes to take such an approach would impose hardships and unusual difficulties without a compensating increase in the level of quality and safety for the following reasons:

a) High Personnel Dose

As mentioned above, a guide cone is attached to the bottom of each CEDM nozzle via a threaded connection. Entergy has estimated that removing and reinstalling the 81 guide cones would result in personnel exposure of approximately 1.25 man-REM per nozzle for a total exposure of 101.25 man-REM.

b) Removing, Redesigning, and Reinstalling Guide Cones

The guide cones would be removed by cutting them off at the top of the nozzle threaded region, which would result in a shorter nozzle below the J-groove weld. As a result, the blind zone would be relocated closer to the weld reducing the length of nozzle below the J-groove weld that could be inspected via UT in future inspections.

The replacement guide cone is of a welded socket design that fits over the end of the nozzle and is welded to the nozzle tube. To reinstall the cones would require a modification to the nozzle ends as well as fabrication of new cones. Having to remove the cones and replace them with new components results in additional modifications to the RPV head that go beyond the requirements and scope of the Order. In addition, installing the new guide cone would cause high residual stresses in the heat affected zone of the weld, which would increase the probability of primary water stress corrosion cracking (PWSCC).

c) Impact on Outage Schedule

Entergy estimates that to remove and reinstall each guide cone would require approximately eight (8) hours per nozzle adding as much as 27 days to the outage schedule.

B. Inspection Probe Design Limitation

1. Description

The inspection probe to be used to inspect ANO-2 CEDM nozzles consists of seven (7) individual transducers, as shown in Figure 3. Various probe configurations will be utilized to perform the UT and ECT inspections [e.g., UT time-of-flight diffraction (TOFD) and standard 0° scans and low frequency ECT.]

The inspection probe is designed so that the ultrasonic transducers are slightly recessed into the probe holder. This recess must be filled with water to provide coupling between the transducer and the nozzle wall. Because of this design, the complete diameter of the transducer must fully contact the inspection surface before ultrasonic information can be collected. Because UT probes 1 and 2 have a diameter of 0.250 inch, these transducers should, in theory, be able to collect meaningful UT data down to a point approximately 0.125 inch (½ diameter) above the chamfer. However, based on prior UT inspection experience and a review of UT data from previous inspections, the circumferential-shooting TOFD transducer pair only collects meaningful data down to a point 0.200 inch above the chamfer. Below this point, UT data cannot be collected.

2. Hardship

Entergy knows of no UT equipment currently available that resolves the blind zone limitation; therefore, new UT equipment would have to be developed and appropriately qualified. The time and resources required to develop this equipment is unknown.

C. Impracticality and Hardship of Performing Alternative Surface Examinations

To perform a PT inspection, the guide cones would have to be removed from and reinstalled on the CEDM nozzles before and after performing the PT examinations. Performing these operations would result in a significant increase in personnel radiation exposure. Entergy estimates that the radiation exposure associated with removing the guide cone, performing the PT inspection, and reinstalling the guide cone to be approximately 2.5 man-REM per nozzle for a total exposure of 202.5 man-REM. In addition, this option would also involve those hardships described in Sections III.A.2.a) and b), above.

As with the UT inspection, the bottom 1.344 inches (threaded connection and chamfer region) of the inside surface of the nozzle cannot be inspected using ECT.

In conclusion, CEDM nozzles can be volumetrically inspected in accordance with Section IV.C.(5)(b)(i) of the Order from 2 inches above the J-groove weld to the top of the blind zone (approximately 1.544 inches above the bottom of the nozzle). Below this point, Entergy believes that the hardships associated with inspection activities required by the Order as discussed above are not commensurate with the level of increased safety or reduction in probability of leakage that would be obtained by complying with the Order.

IV. PROPOSED ALTERNATIVE AND BASIS FOR USE

Paragraph IV.C.(5)(b)(i) of the Order requires that the UT inspection of each RPV head penetration nozzle encompass from 2 inches above the highest point of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) to 2 inches below the lowest point at the toe of the J-groove weld on a horizontal plane perpendicular to the nozzle axis (or the bottom of the nozzle if less than 2 inches); OR from 2 inches above the highest point of the root of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) to 1.0 inch below the lowest point at the toe of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) and including all RPV head penetration nozzle surfaces below the J-groove weld that have an operating stress level (including all residual and normal operating stresses) of 20 ksi tension and greater. In addition, an assessment shall be made to determine if leakage has occurred into the annulus between the RPV head penetration nozzle and the RPV head low-alloy steel.

Due to the reasons stated above, Entergy requests relaxation from this requirement for ANO-2 CEDM nozzles and proposes an alternative, which involves the use of UT examination, analysis, and augmented inspection techniques, as described below.

A. Proposed Alternative

1. UT Examination

The ID of each CEDM nozzle (i.e., nozzle base material) shall be ultrasonically examined from two (2) inches above the J-groove weld to 1.544 inches above the bottom of the nozzle. In addition, an assessment to determine if leakage has occurred into the interference fit zone will be performed, as currently specified in Section IV.C.(5)(b)(i) of the Order.

2. Analysis

For the blind zone portions of the CEDM nozzle not examined by UT as required by the Order, analysis has been performed to:

a) Determine if sufficient free-span exists between the blind zone and the weld to facilitate one (1) operating cycle of crack growth without the crack reaching the weld, and

b) For nozzles or portions of nozzles not meeting item 2.a), above, determine how much propagation length is required to facilitate one cycle of crack growth without the crack reaching the weld. This length is composed of the distance between the weld and the blind zone plus some additional distance into the blind zone. The additional distance into the blind zone area is defined in Table 1 and is subject to augmented inspection as described in item 3 below. This area to be inspected may include a portion of the weld.

The analysis is discussed in further detail in Section IV.B.2 below and is fully documented in Engineering Report M-EP-2003-002, Rev. 1, which was previously submitted to the NRC.[1] The analysis is based on design information and actual UT data obtained during the ANO-2 Spring 2002 refueling outage.

3. Augmented Inspections

CEDM nozzles that have been demonstrated by analysis to have inadequate free-span to facilitate crack growth will be inspected. These nozzles and their associated augmented inspection areas are identified in Table 2. Specifically, an augmented inspection of the outside diameter (OD) will be performed on that portion of the nozzle that has been determined by analysis as necessary to prevent a crack from reaching the J-groove weld in less than one operating cycle. The augmented inspection will utilize either ECT or PT, or a combination of both techniques.

As required by Section IV.E of the Order, the final results of the inspections will be provided in the 60-day report submitted to the NRC.

B. Basis for Use

The UT examination is the volumetric technique recognized in Section IV.C.(5)(b)(i) of the Order. The Entergy proposed alternative includes the use of UT to the maximum extent practical based on the limits of current technology. However, because the technology cannot provide an inspection to the extent required by the Order (i.e., to the bottom of the nozzle), Entergy proposes supplemental analysis and augmented inspection. This approach provides a level of safety and quality commensurate with the intent of the Order. Each portion of the proposed alternative is discussed below.

1. UT Examination

Entergy will perform UT inspection of the ANO-2 CEDM nozzles using a combination of TOFD and standard 0° pulse-echo techniques. The TOFD approach utilizes two pairs of 0.250-inch diameter, 55° refracted-longitudinal wave transducers aimed at each other. One of the transducers sends sound into the inspection volume while the other receives the reflected and diffracted signals as they interact with the material. There will be one TOFD pair looking in the axial direction of the penetration nozzle tube and one TOFD pair looking in the circumferential direction of the tube. The TOFD technique is primarily used to detect and characterize planar-type defects within the full volume of the tube.

The standard 0° pulse-echo ultrasonic approach utilizes one 0.250-inch diameter straight beam transducer. The 0° technique is used to:

- Plot the penetration nozzle OD location and J-groove weld location,
- Locate and size any laminar-type defects that may be encountered, and

[1] Entergy submitted Engineering Report M-EP-2003-002, Rev. 1 to the NRC via Entergy letters CNRO-2003-00033 dated August 27, 2003 and CNRO-2003-00047 dated September 25, 2003.

- Monitor the back-wall signal response to detect leakage that may occur in the interference regions of the RPV head penetration.

The UT inspection procedures and techniques to be utilized at ANO-2 have been satisfactorily demonstrated under the EPRI Materials Reliability Program (MRP) Inspection Demonstration Program.

2. Analysis

The extent of the proposed alternative is established by an engineering evaluation that includes a finite element stress analysis and fracture mechanics evaluations. The intent of the engineering evaluation is to:

a) Determine whether sufficient crack propagation length exists between the tip of a postulated crack and the weld to facilitate one cycle of crack growth without the crack reaching the weld;

b) Where sufficient available crack propagation length does not exist above the blind zone for a given nozzle, then determine how much additional length into the blind zone is required to provide one cycle of crack growth without compromising the weld. See Figure 4.

Four (4) CEDM nozzle locations were selected for analysis in the engineering evaluation. The selected locations (RPV head angles) were 0°, 8.8°, 28.8°, and 49.6° with the 0° head angle at the vertical centerline of the RPV head, the 49.6° head angle location being the outermost nozzles, and the other two being intermediate locations between the center and outermost locations. The results of the stress analysis at each location are bounding for nozzles higher on the head (e.g., analysis for 28.8° bounds the intermediate nozzles between 8.8° and 28.8°). The selected nozzle head angle locations provide an adequate representation of residual stress profiles and a proper basis for analysis to bound all CEDM nozzles.

Based on these analyses, each nozzle was evaluated to determine whether the available propagation length as defined by UT data obtained during the Spring 2002 refueling outage UT is adequate to prevent crack propagation into the weld in less than one cycle of operation. For those nozzles that do not have adequate available propagation length, additional analysis was performed to define the nozzle area that is subject to an augmented inspection.

Stress Analysis

A "finite element" based stress analysis was performed on the ANO-2 CEDM nozzles in this evaluation. For conservatism, the yield strength used in the analysis for each nozzle head angle location is the highest yield strength of all the nozzles at that head angle. To ensure that the finite element analysis (FEA) adequately models the as-built configuration of the selected ANO-2 CEDM nozzles and weld, a detailed review of design drawings and UT inspection data from the ANO-2 Spring 2002 refueling outage was performed. Based on this review, the following was concluded:

- CEDM Nozzles at 0° and 8.8° Head Angle Locations: Weld sizes at each nozzle location are similar to design. However, the as-built nozzle projections below the bottom of the RPV head are shorter than indicated by design. The FEA model was adjusted for this shorter nozzle projection.

- CEDM Nozzles at 28.8° Head Angle Locations: The leg lengths of the welds on the downhill sides of the nozzles are longer than indicated by design. The leg lengths of the fillet weld reinforcement on the uphill side of the nozzles match the design values. Nozzle projections below the bottom of the RPV head are in accordance with design. The FEA model was adjusted to account for the longer weld leg lengths on the downhill side of the nozzles.

- CEDM Nozzles at 49.6° Head Angle Locations: The leg lengths of the welds on the downhill sides of the nozzles are longer than indicated by design and extend into the blind zone. The leg lengths of the welds on the uphill side of the nozzles match the design values. Nozzle projections below the bottom of the RPV head are in accordance with design. The FEA model was adjusted to account for the longer weld leg lengths on the downhill side of the nozzles.

The FEA determined the stress distribution from the bottom of the nozzle to just above the top of the weld at the downhill, uphill, and mid-plane azimuthal locations. The downhill and mid-plane locations were selected because they represent the shortest distances that a crack would have to propagate to reach the nozzle weld region. The uphill location was selected for completeness of the analysis. The stress distributions produced by this analysis were used to perform the fracture mechanics evaluations.

Fracture Mechanics Evaluation

Safety analyses performed by the MRP have demonstrated that axial cracks in the nozzle tube material do not pose a challenge to the structural integrity of the nozzle. However, axial cracks may lead to pressure boundary leaks above the weld that could produce OD circumferential cracks and structural integrity concerns. Therefore, proper analysis of potential axial cracks in the blind zone of the CEDM nozzle is essential.

Postulated cracks for the analysis include axial ID and OD part through-wall and through-wall cracks. Axial cracks were selected for evaluation in this analysis because of their potential to propagate to the weld region. Axial ID and OD part through-wall crack sizes equal the smallest crack sizes successfully detected by UT under the EPRI MRP Inspection Demonstration Program. Through-wall cracks were sized based on the stress distribution in the area of interest. The ID and OD part through-wall and through-wall cracks were located along the circumference of each nozzle at the 0° (downhill), 90° (mid-plane), and 180° (uphill) azimuthal locations, 0° (downhill) being the furthest point from the center of the RPV head.

The analyses performed in the engineering evaluation were designed to determine the behavior of postulated cracks that could exist in the blind zone.

Hence, the crack growth region is from the top of the blind zone to the bottom of the weld. The fracture mechanics evaluation shows that an ID-initiated flaw will not grow through-wall and reach into the weld establishing a leak path within one cycle of operation for any of the nozzle locations.

Twenty-eight (28) different cases were analyzed using crack growth rates from EPRI Report MRP-55, *Material Reliability Program – Crack Growth Rates for Evaluating Primary Water Stress Corrosion Cracking (PWSCC) of Thick-Wall Alloy 600 Material*. In summary, the evaluation results from all cases at the uphill and mid-plane locations indicate that axial cracks in the blind zone will not propagate into the weld region within one cycle of operation. However, in five cases, postulated OD part through-wall and through-wall cracks at the 0° and downhill location of the 8.8° and 28.8° CEDM nozzles were predicted to propagate into the weld in less than one cycle of operation. In two other cases fracture mechanics evaluations could not be performed for OD part through-wall and through-wall cracks at the downhill location of the 49.6° CEDM nozzle due to the extension of the weld into the blind zone. Results of the fracture mechanics evaluations are documented in Table 17 of Engineering Report M-EP-2003-002, Rev. 1 and are summarized in Table 3.

Based on the results of the fracture mechanics evaluation presented in Table 3, the downhill location of ANO-2 CEDM nozzles is the critical location at which a crack could potentially grow from the blind zone to the bottom of the weld in less than one cycle of operation. To assess this crack growth potential at the downhill location of the CEDM nozzles, results from the fracture mechanics analysis were evaluated against UT data obtained from inspection of all eighty-one (81) CEDM nozzles during the ANO-2 Spring 2002 refueling outage. For consistency, the UT data were adjusted to account for initial crack size assumptions in the fracture mechanics analysis. Except for CEDM nozzles at penetrations 6, 7, 9, 20, 25, and 58, the evaluation indicates that cracks could grow into the welds of seventy-five (75) of the 81 CEDM nozzles within one cycle of operation. Therefore, these 75 nozzles will be inspected. The results of this evaluation are documented in Table 4.

Analysis to Determine Needed Crack Propagation Lengths

CEDM nozzles that lack sufficient available crack propagation length will be inspected. For these nozzles, additional analysis was performed to determine how much additional length in the blind zone is required to ensure one cycle of crack growth without compromising the weld. See Figure 2.

The augmented inspection ensures that this additional area in the blind zone is free of PWSCC, thereby providing additional assurance that a crack in the blind zone will not propagate into the weld in less than one cycle of operation. The augmented inspection will utilize the ECT and/or PT examination method(s).

Because analysis has excluded the nozzle ID and a portion of the nozzle OD circumference as locations of unacceptable crack growth, the area of interest is limited to the OD of the downhill azimuthal region of the nozzle.

The boundaries for augmented inspection were established by fracture mechanics. The top of the augmented inspection zone was defined by the upper limit of the blind zone (1.544 inches above the bottom of the nozzle). The bottom and circumferential extent of the augmented inspection zone was determined by analysis. The bottom of the augmented inspection zone was established by first identifying a point at the downhill (0°) azimuthal location from which a crack could not propagate into the weld region within one cycle of operation. Likewise, the circumferential extent of the augmented inspection zone was established by identifying a point along the upper limit of the blind zone from which a crack could not propagate into the weld region in one cycle of operation. Based on the results of this evaluation, augmented inspection zone boundaries were established as shown in Table 1.

As shown in Table 1, the circumferential extent of the augmented surface inspection is less than 360° for the CEDM nozzles located at the 8.8°, 28.8°, and 49.6° head angle. By limiting the inspection to that portion of the nozzle defined by analysis, the effective radiation dose on inspection team personnel will be minimized while providing assurance that PWSCC will not cause a leak during the operating cycle following the inspection.

Conclusion

For details regarding the engineering evaluation and its conclusions, see Engineering Report M-EP-2003-002, Revision 1.

This analysis incorporated a crack-growth formula different from that described in Footnote 1 of the Order, as provided in EPRI Report MRP-55. Entergy is aware that the NRC staff has not yet completed a final assessment regarding the acceptability of the EPRI report. If the NRC staff finds that the crack-growth formula in MRP-55 is unacceptable, Entergy shall revise its analysis that justifies relaxation of the Order within 30 days after the NRC informs Entergy of an NRC-approved crack-growth formula. If Entergy's revised analysis shows that the crack growth acceptance criteria are exceeded prior to the end of Operating Cycle 18 (following the upcoming refueling outage), this relaxation is rescinded and Entergy will, within 72 hours, submit to the NRC written justification for continued operation. If the revised analysis shows that the crack growth acceptance criteria are exceeded during the subsequent operating cycle, Entergy shall, within 30 days, submit the revised analysis for NRC review. If the revised analysis shows that the crack growth acceptance criteria are not exceeded during either Operating Cycle 18 or the subsequent operating cycle, Entergy shall, within 30 days, submit a letter to the NRC confirming that its analysis has been revised. Any future crack-growth analyses performed for Operating Cycle 18 and future cycles for RPV head penetrations will be based on an NRC-acceptable crack growth rate formula.

3. Augmented Inspections

As discussed in Section IV.A.3, above, OD surface examinations are needed due to the inability of the UT probes to inspect the extent of the CEDM nozzles as required by the Order. The Order recognizes and allows combining techniques per Section IV.C.(5)(b)(iii) of the Order.

Entergy believes that by employing analytical and inspection techniques, the proposed alternative discussed above provides an adequate process for inspecting, evaluating, and determining the condition of the ANO-2 RPV head penetration CEDM nozzles with regard to the presence of PWSCC. Therefore, Entergy concludes that the proposed alternative adequately meets the intent of the Order.

V. CONCLUSION

Section IV.F of the Order states in part:

> Licensees proposing to deviate from the requirements of this Order shall seek relaxation of this Order pursuant to the procedure specified below. The Director, Office of Nuclear Reactor Regulation, may, in writing, relax or rescind any of the above conditions upon demonstration by the Licensee of good cause. A request for relaxation regarding inspection of specific nozzles shall also address the following criteria:
>
> (1) The proposed alternative(s) for inspection of specific nozzles will provide an acceptable level of quality and safety, or
>
> (2) Compliance with this Order for specific nozzles would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

Section IV.C.(5)(b) of the Order establishes a minimum set of RPV head penetration nozzle inspection requirements to identify the presence of cracks in penetration nozzles that could lead to leakage of reactor coolant and wastage of RPV head material.

Entergy believes that compliance with the UT inspection provisions of Section IV.C.(5)(b)(i) of the Order as described in Section II above would result in hardships and unusual difficulties, as discussed in Section III above, without a compensating increase in the level of quality and safety.

Entergy believes the proposed alternative, described in Section IV, provides an acceptable level of quality and safety by utilizing inspections and supplemental analysis to determine the condition of the ANO-2 CEDM nozzles. The technical basis for the supplemental analysis and the augmented inspections of the proposed alternative is documented in Engineering Report M-EP-2003-002, Rev. 1, which was previously submitted to the NRC staff. Therefore, Entergy requests that the proposed alternative be authorized pursuant to Section IV.F of the Order.

TABLE 1

AUGMENTED SURFACE INSPECTION

CEDM Location	Nozzle Azimuth Location	Boundary for Augmented Surface Examination [1]			
		Top Elevation	Bottom Elevation	Axial Length	Circumferential Extent [2]
0°	Downhill	1.544"	1.090"	0.454"	DH ± 180°
8.8°	Downhill	1.544"	1.090"	0.454"	DH ± 67.5°
28.8°	Downhill	1.544"	1.224"	0.320"	DH ± 22.5°
49.6°	Downhill	1.544"	0.883"	0.661"	DH ± 45°

Notes:

1. Measured from the bottom end of the nozzle.
2. "DH" = "downhill"

TABLE 2

Evaluation of CEDM Nozzles for Augmented Inspection

CEDM Nozzle		Selected for Augmented Inspection (1)	Augmented Inspection Boundary (referenced from bottom of nozzle)			
No.	Head Angle		Top Elevation	Bottom Elevation	Axial Length	Azimuthal Location and Circumferential Extent
1	0°	Yes	1.544"	1.090"	0.454"	Downhill ± 180°
2	8.8°	Yes	1.544"	1.090"	0.454"	Downhill ± 67.5°
3	8.8°	Yes	N/A	N/A	N/A	N/A
4	8.8°	Yes	N/A	N/A	N/A	N/A
5	8.8°	Yes	N/A	N/A	N/A	N/A
6	12.4°	No (2)	N/A	N/A	N/A	N/A
7	12.4°	No (2)	N/A	N/A	N/A	N/A
8	12.4°	Yes	N/A	N/A	N/A	N/A
9	12.4°	No (2)	N/A	N/A	N/A	N/A
10	17.7°	Yes	1.544"	1.224"	0.320"	Downhill ± 22.5°
11	17.7°	Yes	N/A	N/A	N/A	N/A
12	17.7°	Yes	N/A	N/A	N/A	N/A
13	17.7°	Yes	N/A	N/A	N/A	N/A
14	19.9°	Yes	N/A	N/A	N/A	N/A
15	19.9°	Yes	1.544"	1.224"	0.320"	Downhill ± 22.5°
16	19.9°	Yes	1.544"	1.224"	0.320"	Downhill ± 22.5°
17	19.9°	Yes	N/A	N/A	N/A	N/A
18	19.9°	Yes	N/A	N/A	N/A	N/A
19	19.9°	Yes	N/A	N/A	N/A	N/A
20	19.9°	No (2)	N/A	N/A	N/A	N/A
21	19.9°	Yes	N/A	N/A	N/A	N/A
22	25.5°	Yes	N/A	N/A	N/A	N/A
23	25.5°	Yes	N/A	N/A	N/A	N/A
24	25.5°	Yes	1.544"	1.224"	0.320"	Downhill ± 22.5°
25	25.5°	No (2)	N/A	N/A	N/A	N/A
26	27.2°	Yes	N/A	N/A	N/A	N/A
27	27.2°	Yes	N/A	N/A	N/A	N/A
28	27.2°	Yes	1.544"	1.224"	0.320"	Downhill ± 22.5°
29	27.2°	Yes	1.544"	1.224"	0.320"	Downhill ± 22.5°
30	28.8°	Yes	N/A	N/A	N/A	N/A
31	28.8°	Yes	N/A	N/A	N/A	N/A
32	28.8°	Yes	N/A	N/A	N/A	N/A
33	28.8°	Yes	N/A	N/A	N/A	N/A
34	28.8°	Yes	N/A	N/A	N/A	N/A
35	28.8°	Yes	N/A	N/A	N/A	N/A
36	28.8°	Yes	N/A	N/A	N/A	N/A
37	28.8°	Yes	N/A	N/A	N/A	N/A
38	33.3°	Yes	N/A	N/A	N/A	N/A
39	33.3°	Yes	N/A	N/A	N/A	N/A
40	33.3°	Yes	N/A	N/A	N/A	N/A
41	33.3°	Yes	N/A	N/A	N/A	N/A
42	33.3°	Yes	N/A	N/A	N/A	N/A
43	33.3°	Yes	N/A	N/A	N/A	N/A
44	33.3°	Yes	N/A	N/A	N/A	N/A

CEDM Nozzle		Selected for Augmented Inspection [1]	Augmented Inspection Boundary (referenced from bottom of nozzle)			
No.	Head Angle		Top Elevation	Bottom Elevation	Axial Length	Azimuthal Location and Circumferential Extent
45	33.3°	Yes	N/A	N/A	N/A	N/A
46	37.6°	Yes	N/A	N/A	N/A	N/A
47	37.6°	Yes	N/A	N/A	N/A	N/A
48	37.6°	Yes	N/A	N/A	N/A	N/A
49	37.6°	Yes	N/A	N/A	N/A	N/A
50	38.9°	Yes	N/A	N/A	N/A	N/A
51	38.9°	Yes	N/A	N/A	N/A	N/A
52	38.9°	Yes	N/A	N/A	N/A	N/A
53	38.9°	Yes	N/A	N/A	N/A	N/A
54	38.9°	Yes	N/A	N/A	N/A	N/A
55	38.9°	Yes	N/A	N/A	N/A	N/A
56	38.9°	Yes	N/A	N/A	N/A	N/A
57	38.9°	Yes	N/A	N/A	N/A	N/A
58	40.3°	No [2]	N/A	N/A	N/A	N/A
59	40.3°	Yes	1.544"	0.883"	0.661"	Downhill ± 45.0°
60	40.3°	Yes	1.544"	0.883"	0.661"	Downhill ± 45.0°
61	40.3°	Yes	1.544"	0.883"	0.661"	Downhill ± 45.0°
62	43.0°	Yes	1.544"	0.883"	0.661"	Downhill ± 45.0°
63	43.0°	Yes	1.544"	0.883"	0.661"	Downhill ± 45.0°
64	43.0°	Yes	1.544"	0.883"	0.661"	Downhill ± 45.0°
65	43.0°	Yes	1.544"	0.883"	0.661"	Downhill ± 45.0°
66	43.0°	Yes	1.544"	0.883"	0.661"	Downhill ± 45.0°
67	43.0°	Yes	1.544"	0.883"	0.661"	Downhill ± 45.0°
68	43.0°	Yes	N/A	N/A	N/A	N/A
69	43.0°	Yes	N/A	N/A	N/A	N/A
70	49.6°	Yes	N/A	N/A	N/A	N/A
71	49.6°	Yes	N/A	N/A	N/A	N/A
72	49.6°	Yes	N/A	N/A	N/A	N/A
73	49.6°	Yes	N/A	N/A	N/A	N/A
74	49.6°	Yes	N/A	N/A	N/A	N/A
75	49.6°	Yes	N/A	N/A	N/A	N/A
76	49.6°	Yes	N/A	N/A	N/A	N/A
77	49.6°	Yes	N/A	N/A	N/A	N/A
78	49.6°	Yes	N/A	N/A	N/A	N/A
79	49.6°	Yes	N/A	N/A	N/A	N/A
80	49.6°	Yes	N/A	N/A	N/A	N/A
81	49.6°	Yes	N/A	N/A	N/A	N/A

Notes for Table 2:

1. CEDM nozzles are subject to augmented inspection under either of the following conditions:
   - Postulated cracks can grow from the blind zone into the weld within one cycle of plant operation
   - The nozzle attachment weld extends into the blind zone region.
2. This nozzle is excluded from augmented inspection based on the fracture mechanics evaluation and available crack propagation length (see Table 4).

TABLE 3

Results of Crack Growth Analysis

CEDM Location (Head Angle)	Nozzle Azimuth Location	Axial Crack Evaluated	Crack Evaluation Results
0°	All	ID Part through-wall	Greater than 1 Cycle to reach Weld
		OD Part through-wall	**Less than 1 Cycle to reach Weld**
		Through-wall	**Less than 1 Cycle to reach Weld**
8.8°	Downhill	ID Part through-wall	Greater than 1 Cycle to reach Weld
		OD Part through-wall	**Less than 1 Cycle to reach Weld**
		Through-wall	**Less than 1 Cycle to reach Weld**
	Uphill	ID Part through-wall	Greater than 1 Cycle to reach Weld
		OD Part through-wall	Greater than 1 Cycle to reach Weld
		Through-wall	Greater than 1 Cycle to reach Weld
	Mid-plane	ID Part through-wall	Greater than 1 Cycle to reach Weld
		OD Part through-wall	Greater than 1 Cycle to reach Weld
		Through-wall	Greater than 1 Cycle to reach Weld
28.8°	Downhill	ID Part through-wall	Greater than 1 Cycle to reach Weld
		OD Part through-wall	**Less than 1 Cycle to reach Weld**
		Through-wall	Greater than 1 Cycle to reach Weld
	Uphill	ID Part through-wall	Greater than 1 Cycle to reach Weld
		OD Part through-wall	Greater than 1 Cycle to reach Weld
		Through-wall	Greater than 1 Cycle to reach Weld
	Mid-plane	ID Part through-wall	Greater than 1 Cycle to reach Weld
		OD Part through-wall	Greater than 1 Cycle to reach Weld
		Through-wall	Greater than 1 Cycle to reach Weld
49.6°	Downhill	ID Part through-wall	Greater than 1 Cycle to reach Weld
		OD Part through-wall	**Not analyzed - weld extends into blind zone**
		Through-wall	**Not analyzed - weld extends into blind zone**
	Uphill	ID Part through-wall	Greater than 1 Cycle to reach Weld
		OD Part through-wall	Greater than 1 Cycle to reach Weld
		Through-wall	Greater than 1 Cycle to reach Weld
	Mid-plane	ID Part through-wall	Greater than 1 Cycle to reach Weld
		OD Part through-wall	Greater than 1 Cycle to reach Weld
		Through-wall	Greater than 1 Cycle to reach Weld

TABLE 4

CEDM NOZZLES AUGMENTED INSPECTION

Penetration		Analytical Crack Growth Per Cycle[1]	Available Propagation Length Based on UT Data[5]	Crack Growth Into Weld Within 1 Cycle
No.	Head Angle			
1	0°	0.576"	0.32"	Yes
2	8.8°	0.560"	0.24"	Yes
3	8.8°	0.560"	0.16"	Yes
4	8.8°	0.560"	0.18"	Yes
5	8.8°	0.560"	0.32"	Yes
6	12.4°	0.086" [2]	0.28"	No
7	12.4°	0.086" [2]	0.16"	No
8	12.4°	0.086" [2]	0.040"	Yes
9	12.4°	0.086" [2]	0.32"	No
10	17.7°	0.086" [2]	0.000"	Yes
11	17.7°	0.086" [2]	0.000"	Yes
12	17.7°	0.086" [2]	0.000"	Yes
13	17.7°	0.086" [2]	0.000"	Yes
14	19.9°	0.086" [2]	0.000"	Yes
15	19.9°	0.086" [2]	0.000"	Yes
16	19.9°	0.086" [2]	0.000"	Yes
17	19.9°	0.086" [2]	0.000"	Yes
18	19.9°	0.086" [2]	0.080"	Yes
19	19.9°	0.086" [2]	0.000"	Yes
20	19.9°	0.086" [2]	0.320"	No
21	19.9°	0.086" [2]	0.080"	Yes
22	25.5°	0.086" [2]	0.000"	Yes
23	25.5°	0.086" [2]	0.000"	Yes
24	25.5°	0.086" [2]	0.000"	Yes
25	25.5°	0.086" [2]	0.120"	No
26	27.2°	0.086" [2]	0.000"	Yes
27	27.2°	0.086" [2]	0.000"	Yes
28	27.2°	0.086" [2]	0.080"	Yes
29	27.2°	0.086" [2]	0.000"	Yes
30	28.8°	0.086"	0.000"	Yes
31	28.8°	0.086"	0.040"	Yes
32	28.8°	0.086"	0.000"	Yes
33	28.8°	0.086"	0.000"	Yes
34	28.8°	0.086"	0.040"	Yes
35	28.8°	0.086"	0.000"	Yes
36	28.8°	0.086"	0.000"	Yes
37	28.8°	0.086"	0.080"	Yes
38	33.3°	(3)	0.000"	Yes
39	33.3°	(3)	0.000"	Yes
40	33.3°	(3)	0.000"	Yes
41	33.3°	(3)	0.000"	Yes
42	33.3°	(3)	0.000"	Yes
43	33.3°	(3)	0.000"	Yes

Penetration		Analytical Crack Growth Per Cycle[1]	Available Propagation Length Based on UT Data[5]	Crack Growth Into Weld Within 1 Cycle
No.	Head Angle			
44	33.3°	(3)	0.080"	Yes
45	33.3°	(3)	0.000"	Yes
46	37.6°	(3)	0.000"	Yes
47	37.6°	(3)	0.000"	Yes
48	37.6°	(3)	No Data	Yes
49	37.6°	(3)	No Data	Yes
50	38.9°	(3)	No Data	Yes
51	38.9°	(3)	0.000"	Yes
52	38.9°	(3)	0.000"	Yes
53	38.9°	(3)	No Data	Yes
54	38.9°	(3)	0.000"	Yes
55	38.9°	(3)	0.000"	Yes
56	38.9°	(3)	0.000"	Yes
57	38.9°	(3)	0.000"	Yes
58	40.3°	(3)	0.160"	No
59	40.3°	(3)	0.080"	Yes
60	40.3°	(3)	0.080"	Yes
61	40.3°	(3)	0.000"	Yes
62	43.0°	(3)	0.000"	Yes
63	43.0°	(3)	0.040"	Yes
64	43.0°	(3)	0.040"	Yes
65	43.0°	(3)	0.000"	Yes
66	43.0°	(3)	0.000"	Yes
67	43.0°	(3)	0.080"	Yes
68	43.0°	(3)	0.000"	Yes
69	43.0°	(3)	0.000"	Yes
70	49.6°	(4)	0.000"	Yes
71	49.6°	(4)	0.000"	Yes
72	49.6°	(4)	0.000"	Yes
73	49.6°	(4)	0.000"	Yes
74	49.6°	(4)	0.000"	Yes
75	49.6°	(4)	0.000"	Yes
76	49.6°	(4)	0.000"	Yes
77	49.6°	(4)	0.000"	Yes
78	49.6°	(4)	0.000"	Yes
79	49.6°	(4)	0.000"	Yes
80	49.6°	(4)	0.000"	Yes
81	49.6°	(4)	0.000"	Yes

Notes for Table 4:

1. Allowable Propagation Length and Crack Growth Distance per Cycle are obtained from Table 17 of the Engineering Report.

2. CEDM nozzles at the 12.4°, 17.7°, 19.9°, 25.5°, and 27.2° locations are bounded by fracture mechanics analysis results on CEDM nozzles at the 28.8° nozzle location.

3. CEDM nozzles at the 33.3°, 37.6°, 38.9°, 40.3°, and 43.0° locations are bounded fracture mechanics analysis results on CEDM nozzles at the 49.6° nozzle locations. However, because the weld extends into the blind zone of the 49.6° nozzle at the downhill azimuthal location, a fracture mechanics analysis could not be performed for the OD part through-wall and through-wall cracks.

4. For CEDM nozzles at the 49.6° location, the weld extends into "blind zone". Therefore, there is no "Available Propagation Length" at this nozzle location.

5. The "Available Propagation Length Based on UT Data" is based on UT data obtained during the ANO-2 Spring 2002 refueling outage. For CEDM nozzles at the 12.4°, 17.7°, 19.9°, 25.5°, 27.2°, and 28.8° locations, this length is shortened by 0.160" to account for initial crack size assumptions in the analysis.

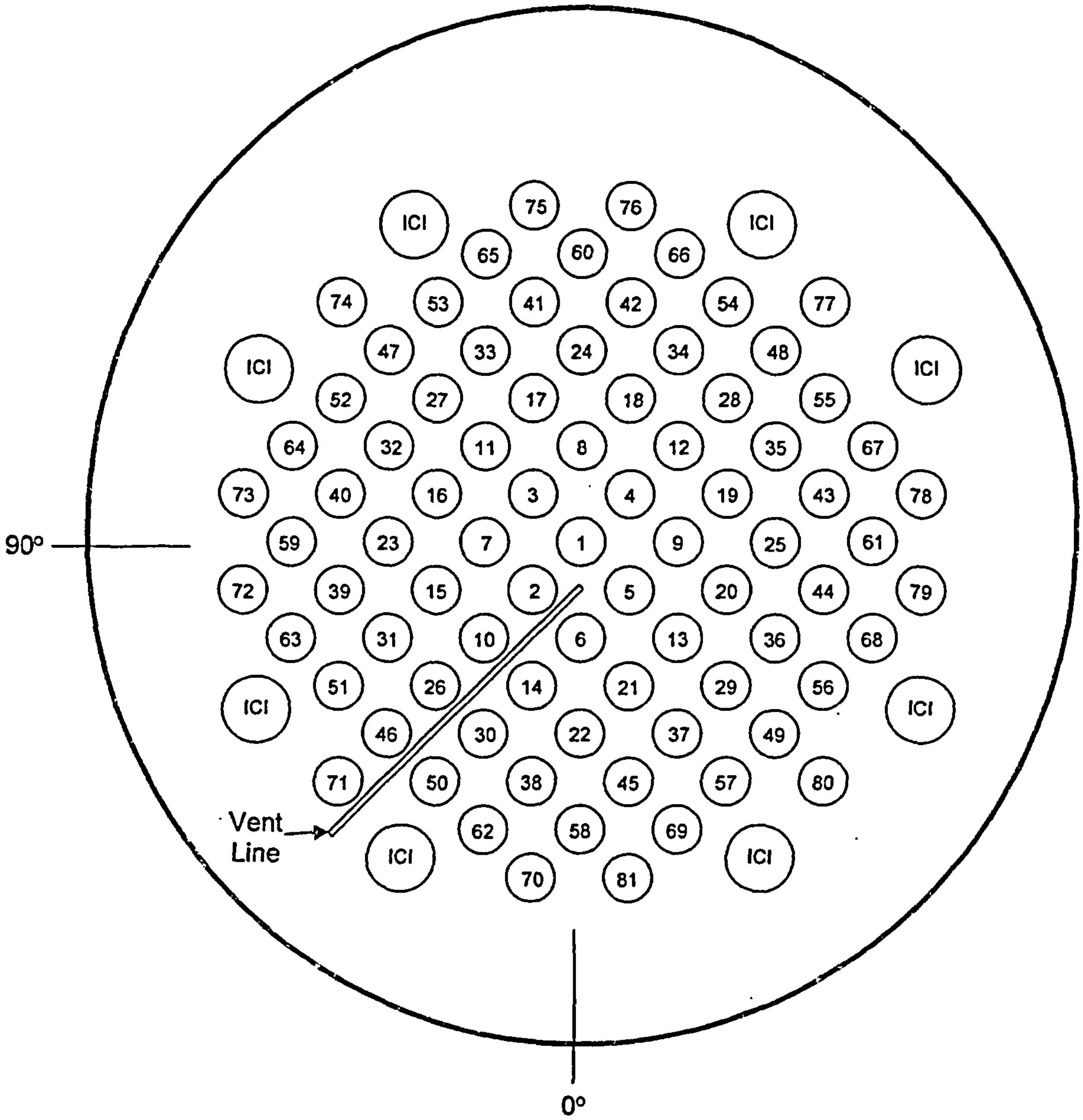


FIGURE 1
PENETRATION LOCATIONS IN THE ANO-2 RPV HEAD

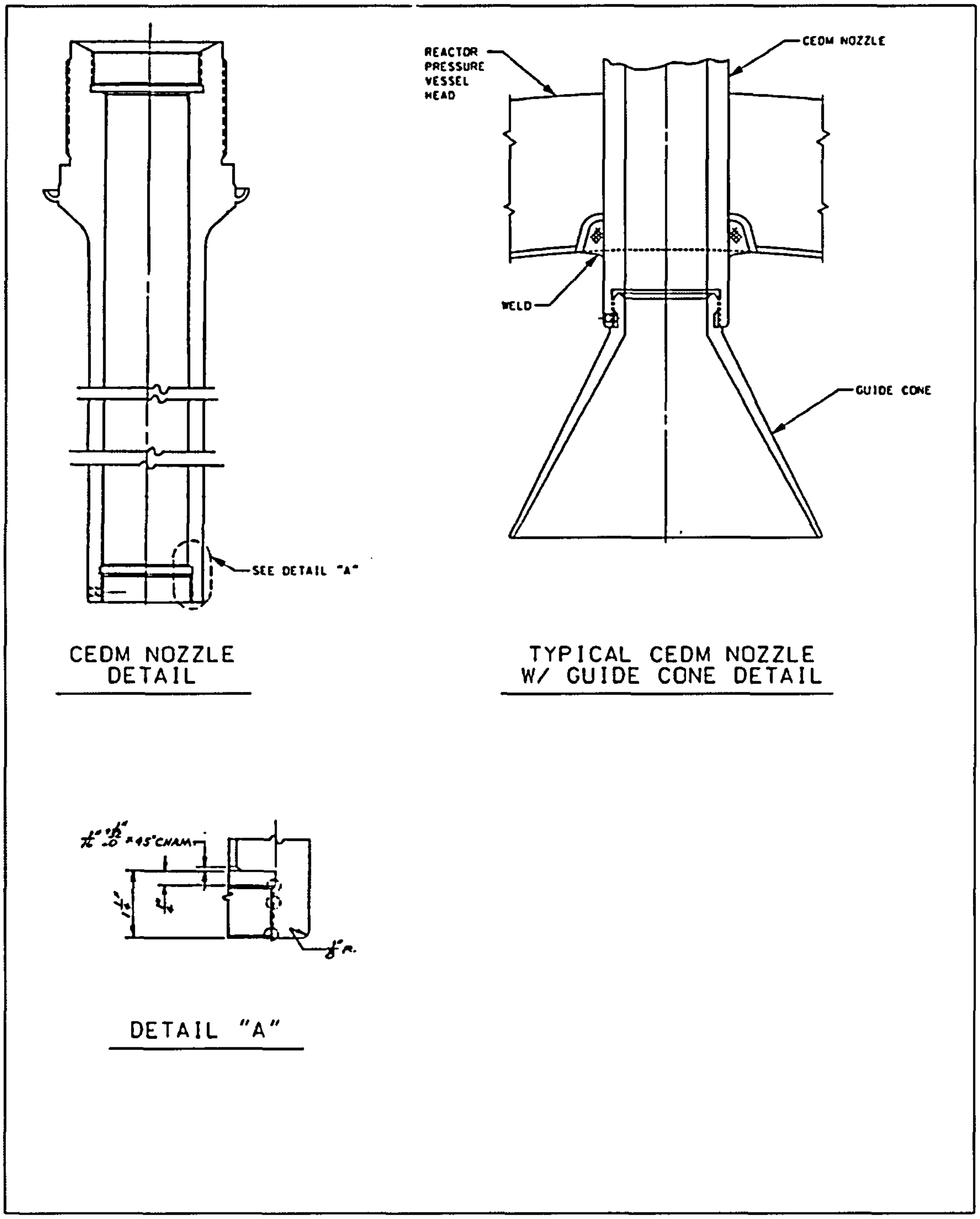
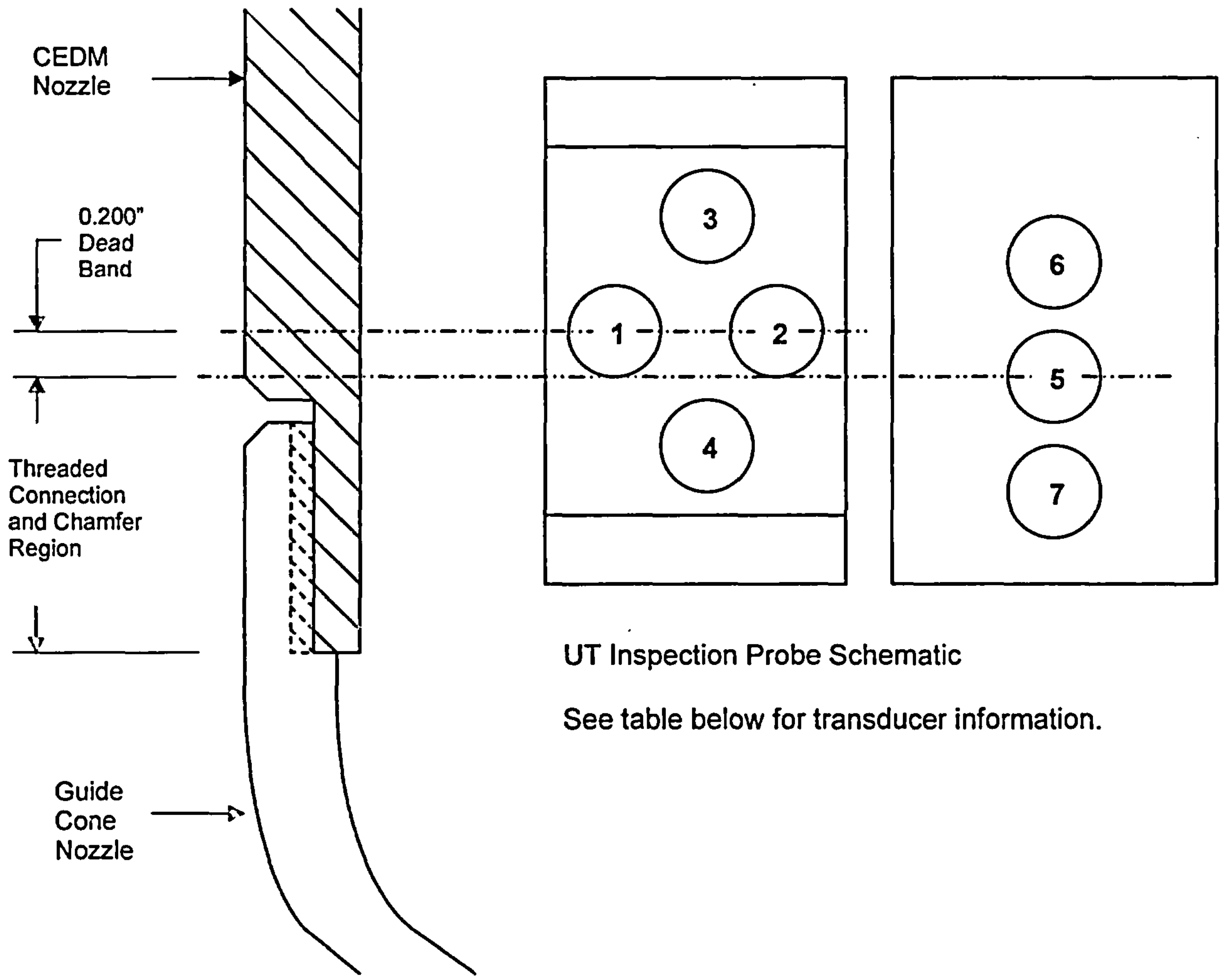


FIGURE 2
TYPICAL CEDM NOZZLE DETAILS



UT Inspection Probe Schematic

See table below for transducer information.

Position	Mode	Diameter	Description
1	Transmit	0.25 inch	Circumferential Scan Using TOFD
2	Receive	0.25 inch	Circumferential Scan Using TOFD
3	Transmit	0.25 inch	Axial Scan Using TOFD
4	Receive	0.25 inch	Axial Scan Using TOFD
5	Transmit Receive	0.25 inch	Standard Zero Degree Scan
6	Transmit Receive	0.25 inch	Low Frequency Eddy Current
7	N/A	0.25 inch	Eddy Current

FIGURE 3
TYPICAL UT INSPECTION PROBE DETAIL

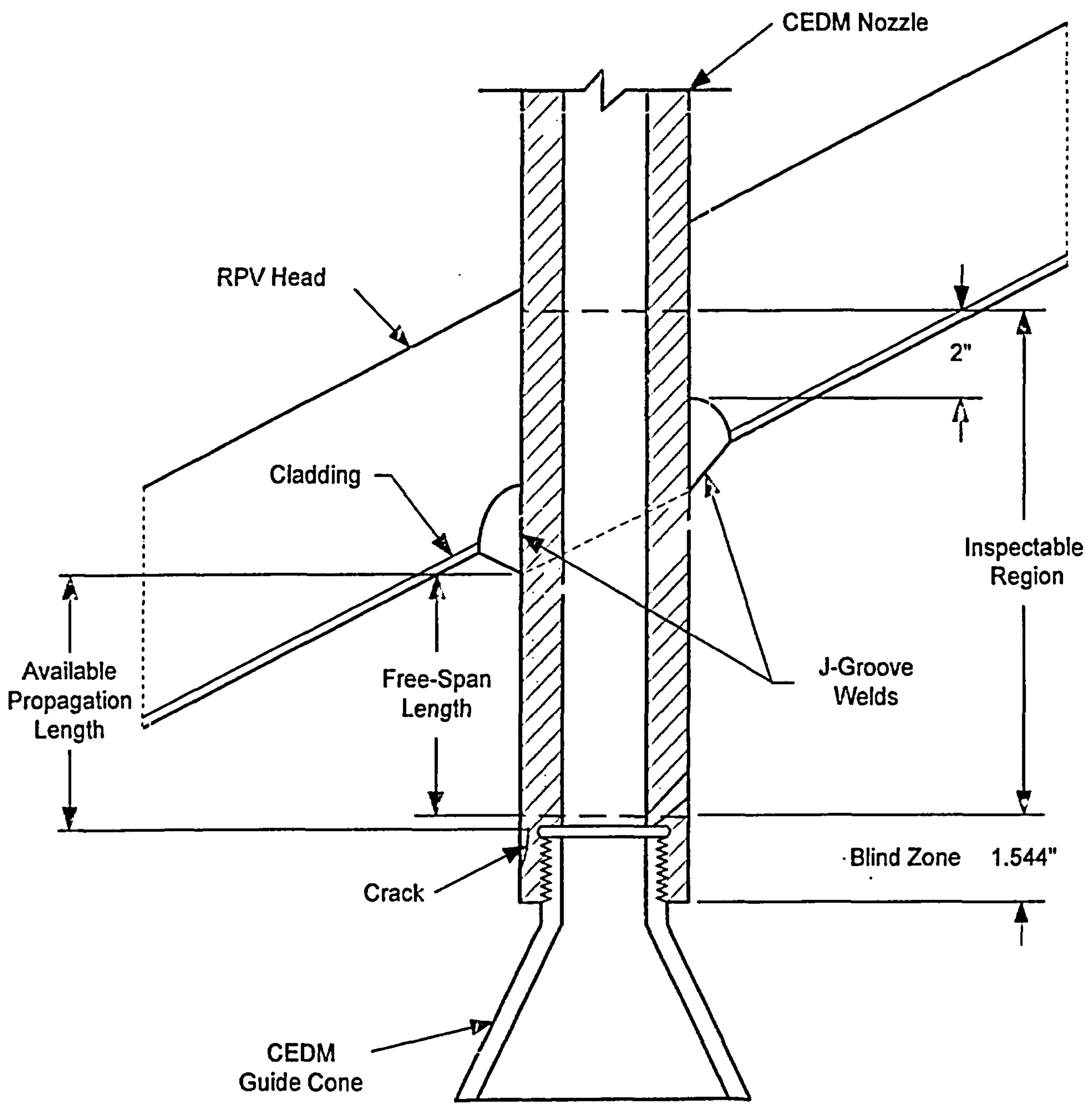


FIGURE 4
DETAIL OF CEDM NOZZLE CRACK GROWTH ANALYSIS

ENCLOSURE 2

CNRO-2004-00018

LICENSEE-IDENTIFIED COMMITMENTS

Enclosure 2 to
CNRO-2004-00018

LICENSEE-IDENTIFIED COMMITMENTS

COMMITMENT	TYPE (Check one)		SCHEDULED COMPLETION DATE
	ONE-TIME ACTION	CONTINUING COMPLIANCE	
1. As required by Section IV.E of the Order, the final results of the inspections will be provided in the 60-day report submitted to the NRC.		✓	60 days after startup from each refueling outage
2. If the NRC staff finds that the crack-growth formula in MRP-55 is unacceptable, Entergy shall revise its analysis that justifies relaxation of the Order within 30 days after the NRC informs Entergy of an NRC-approved crack-growth formula.	✓		Within 30 days after the NRC informs Entergy of an NRC-approved crack-growth formula.
3. If Entergy's revised analysis shows that the crack growth acceptance criteria are exceeded prior to the end of Operating Cycle 18 (following the upcoming refueling outage), this relaxation is rescinded and Entergy will, within 72 hours, submit to the NRC written justification for continued operation.	✓		Within 72 hours from completing the revised analysis in #2, above.
4. If the revised analysis shows that the crack growth acceptance criteria are exceeded during the subsequent operating cycle, Entergy shall, within 30 days, submit the revised analysis for NRC review.	✓		Within 30 days from completing the revised analysis in #2, above.
5. If the revised analysis shows that the crack growth acceptance criteria are not exceeded during either Operating Cycle 18 or the subsequent operating cycle, Entergy shall, within 30 days, submit a letter to the NRC confirming that its analysis has been revised.	✓		Within 30 days from completing the revised analysis in #2, above.
6. Any future crack-growth analyses performed for Operating Cycle 18 and future cycles for RPV head penetrations will be based on an NRC-acceptable crack growth rate formula.		✓	N/A